
Space Weather Technical Forecast

Issued on Sunday, 21 January 2024 at 13:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Large Earth-directed CME arrival forecast for 22 January with a likelihood of Moderate Geomagnetic Storm and a chance of Strong Geomagnetic Storms. Risk easing into 23 January. Increased risk of Moderate solar activity.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the last 24 hours, with the majority of high-level C-class flare activity from AR3559, a large and magnetically complex sunspot region in the northeast of the solar disc. This has recently developed a delta region in the centre of the region, contributing to an increased risk of Moderate flares. AR3561 and AR3562 in the south centre disc have also increased less dramatically in complexity and continue to be monitored. These are three of 10 sunspot regions on the visible disc, with the remaining regions either stable or fading, with negligible activity.

A dimming of the visible disc was observed around 21/0140UTC, but this does not appear to have led to a CME, with no Earth-directed CMEs observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, observed by DSCOVR at L1 have been at slightly elevated levels between 400-450km/s with a decreasing trend. Density was below average. Total magnetic field strength has been weak, with the north-south component also varying weakly. Phi angle was mainly positive (away from the Sun). Resultant geomagnetic activity has been Quiet.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was at Background levels. GOES16 high energy (greater than 2MeV) electron flux was at background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold on a steady trend. At 21/0001UTC the 24-hour integrated fluence observation was 1.44e6 integrated pfu.

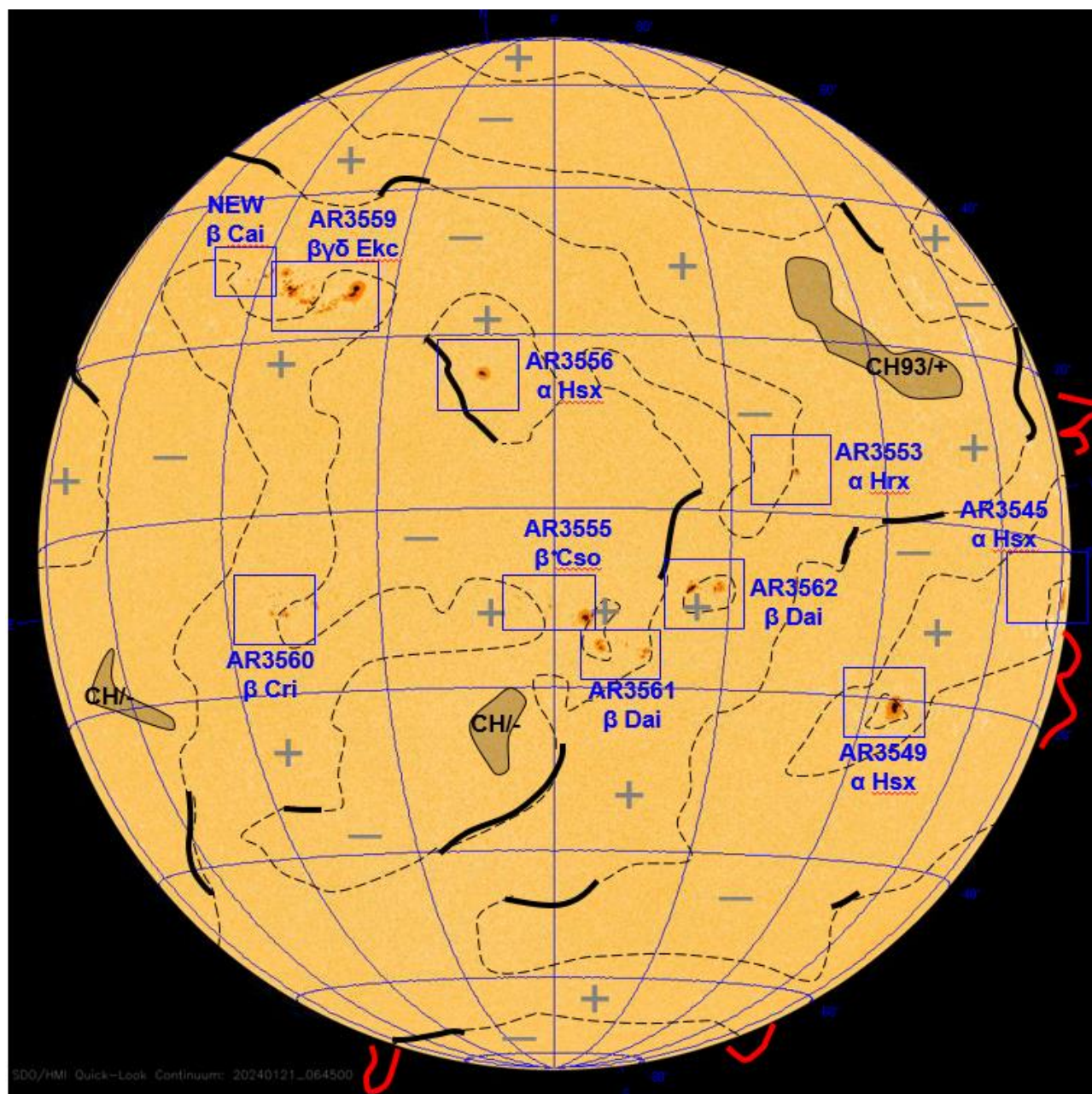
Four-Day Space Weather Forecast Summary

Solar Activity: There is a likelihood of M-class flares and a very slight chance of X-class flaring during the next four days, mainly from AR3559.

Solar Wind / Geomagnetic Activity: A CME which left the Sun early on 20 January is forecast to arrive at Earth, either later on 22 January or early on 23 January, moving at an estimated speed of 950km/s. Otherwise a high speed stream from coronal hole 93 may connect with the Earth during 21 January, but with a declining probability through the day. If the feature connects, speeds of up to 500km/s are possible. Geomagnetic activity may reach Active levels due to any coronal hole high speed stream connection. The CME arrival may increase geomagnetic activity to G1/Minor or G2/Moderate storm levels from late on 22 January, with a slight chance of G3/Strong storm levels. Any activity should then decline slowly on 24 January.

Energetic Particles / Solar Radiation: There is a slight chance of proton flux reaching S1/Minor Storm levels due to either a flare from AR3559 or due to the CME arrival on 22 January or 23 January. This risk will also increase as AR3559 rotates into the western hemisphere. The high energy electron flux is expected to start at background levels, with the possible fast wind from CH93 and an inbound CME significantly increasing uncertainty through the period. There is a very slight chance of Active 24-hour integrated fluence at the end of the period.

Figure 1. Solar Analysis Valid 21/0800 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

A CME which left the Sun around 20/0840 UTC from the southeast quadrant is forecast to arrive at Earth from late on 22 January, with a decreasing likelihood into 23 January. Initial analysis of this eruption was complicated by a concurrent eruption from the northeast quadrant. Analysis has since settled on a speed of around 950km/s, but Enlil is over forecasting the solar wind by around 100km/s, which is leading to the modelled arrival time being advanced. Considering these factors and that a forecast high speed stream has not materialised, leads to a forecast approximate arrival time of between 22/1500-22/1800UTC, although this will be refined should the fast wind materialise or should forecast winds in Enlil decrease.

Otherwise, the Earth is apparently being influenced by the declining high speed stream from coronal hole 92. A further coronal hole high speed stream, from coronal hole 93 was forecast to connect in the last 24 hours. Any response from this was expected to be weak, due to the size of the feature and positive polarity, with an unfavourable connection likely. Should the high speed stream connect, speeds of around 500km/s are possible.

Quiet to Unsettled at first, with a chance of Active intervals if the coronal hole high speed stream connects with earth. Any effects of this are expected to decline before the forecast arrival of the 20 Jan CME, with the greatest likelihood of G1/G2 Minor/Moderate activity late on 22 January, but with a likelihood of activity into 23 January. There is also a chance of G3/Strong storms associated with the arrival. Depending on the strength of storming post arrival, there is a slight chance of G1 storming into 24 January.

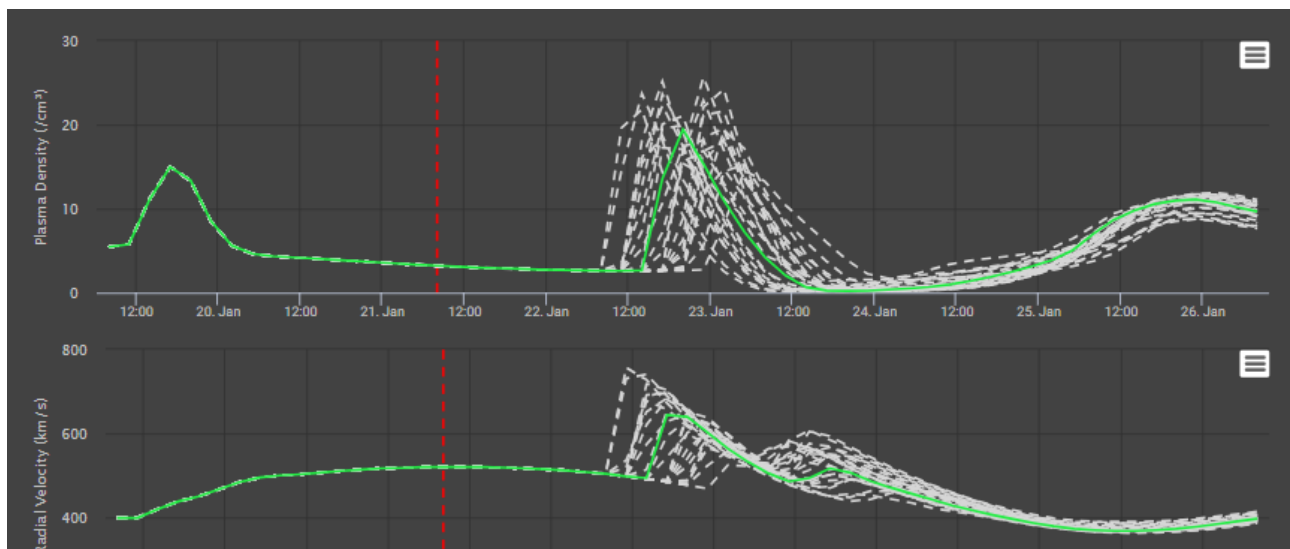
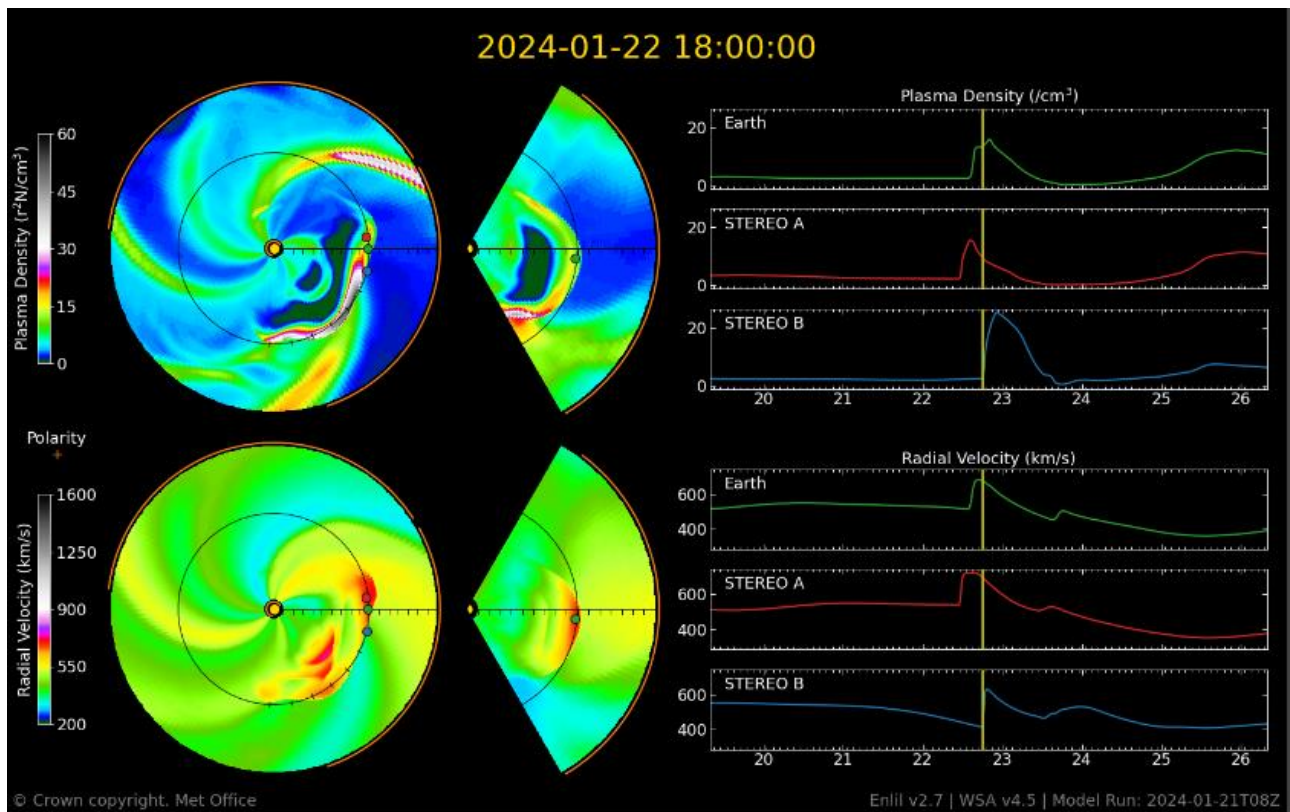
Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	80	50	10
Strong	G3	No	1	30	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/1302	Partial	Filament	SE centre disc	953	22/1800UTC	Uncertainty due to errors in background model wind field.



Figure 2: Latest MOSWOC ENLIL and ENLIL ensemble output indicating a direct CME arrival either late on 22 January or during 23 January. The main source of uncertainty is due to the background wind field being around 100km/s above that observed at DSCOVR.



Radio Blackouts - X-Ray Flares:

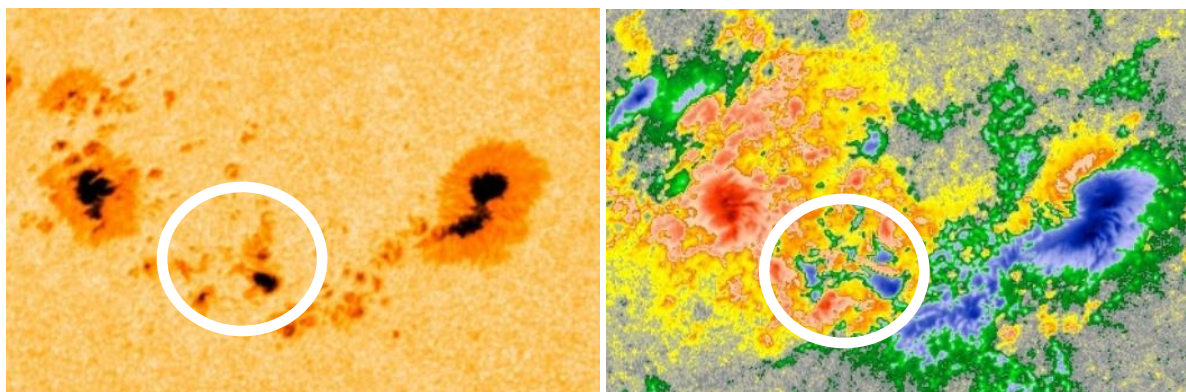
Solar activity has been Low, but AR3559 in the northeast quadrant has significantly developed in both in appearance and magnetic complexity, with a strengthening delta spot in the centre of the region, giving the highest risk of M-class activity. However analysis of the magnetic structure suggests an increasing potential for X-class flare activity. Two regions, AR3561 and AR3562 in the south centre disc have also developed in arrangement and contribute so the flare risk. The remaining regions appear to be simple or are fading.

There are no significant regions expected to rotate into the visible disc in the next four days, with only two stable and inactive regions rotating of the visible disc of the Sun.

Overall the risk of M-class flares have been increased in response to sunspot develops, but is still below that predicted by raw values based on observations. A consequent risk of X-class risk has also be highlighted in the percentage risks.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: SDO HMI and magnetogram imagery of AR3559 (Ekc/ $\beta\gamma\delta$) in the northeast quadrant. The delta portion of the sunspot has been circled)



Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux is currently at background, having shown no response to the long-period C-class flares from the filament and prominence eruptions observed in the period.

There is a slight chance of reaching the S1 Minor Radiation Storm threshold in response to any notable flares, mainly from AR3559 with this continuing to rise slightly as this region rotates into the western hemisphere and as the CME arrives.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	10	15	15	15
Very Active	$\geq \text{S3}$ *	No	1	1	1	1

* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) is at background levels. An increase to moderate levels is possible due to any possible high speed stream arrival. The CME arrival is likely to initially distort the belts away from GEO, given the high speed and density, but then an increased electron population and relaxation of the belts could lead to a trend towards high levels on diurnal maximums, although this is low confidence given uncertainties in the parameters surrounding the CME arrival.

Electron fluence values are extremely muted with a slight chance of Active intervals as electron flux values may increase later in the period.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	5	10
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1